

The following text will be inserted into Chapter 7, Water Quality Attainment Strategies including Total Maximum Daily Loads (TMDLs).

Lagunitas Creek Fine Sediment Reduction and Habitat Enhancement Plan

The following sections establish:

1. A sediment TMDL defining the allowable amount of sediment that can be discharged into Lagunitas Creek, expressed as a percentage of the natural background sediment delivery rate to channels
2. An implementation plan to achieve the TMDL and substantial habitat enhancement in channel reaches that support coho salmon, steelhead, and/or California freshwater shrimp.

The goals of the Lagunitas Creek Sediment Reduction and Habitat Enhancement Plan (Plan) are as follows:

- To restore an annual spawning run within the Lagunitas Creek watershed of 1300-or-more adult coho salmon, achieved for at least twelve consecutive years.
- For native fish and aquatic wildlife species to be in good condition at the individual, population, and community levels.
- To protect and enhance the aesthetic and recreational values of the creek and its tributaries.

The main focus of this Plan is habitat enhancement, because this appears to be a primary cause of the declines of watershed populations of coho salmon, steelhead, and California freshwater shrimp. The Plan also establishes a regulatory program to reduce sediment delivery to channels resulting from road-related erosion, a necessary condition to support recovery of listed species and achieve water quality objectives for sediment and settleable material. Other significant land-use related sediment sources are already being reduced substantially through existing regulatory programs and/or natural recovery processes.

Problem Statement

Due to excess erosion and sedimentation in the Lagunitas Creek watershed, the narrative water quality objectives for sediment and settleable material are not being met, and cold freshwater habitat, wildlife habitat, fish spawning, recreation, and preservation of rare and endangered species beneficial uses are impaired. In addition, the narrative water quality objective for population and community ecology is not being met due to habitat simplification, which is a primary cause for the decline of coho salmon and steelhead trout populations.

Lagunitas Creek provides essential habitat for coho salmon, steelhead trout, and California freshwater shrimp, all of which are listed under the federal Endangered Species Act. During the historical period - the mid-nineteenth century through present - there has been a precipitous decline in the abundance of coho salmon and steelhead in the Lagunitas Creek watershed. Coho salmon and steelhead runs once numbered in the several thousands. Up until the late 1960s, Lagunitas Creek was a popular destination for sport fisherman hoping to catch steelhead and coho salmon. In 1996, Lagunitas Creek's salmon and steelhead populations had dropped so low, that they were listed under the Endangered Species Act.

The most important causes for coho salmon and steelhead population declines in the Lagunitas Creek watershed appear to be: a) the loss of about half of the potential habitat, that has been inundated and/or is no longer accessible as a result of dam construction; and b) in almost all the remaining habitat, the fact that channel incision has greatly simplified habitat and disconnected the channel from its floodplain.

Channel incision causes habitat simplification, which herein is defined as the progressive lowering over time of the streambed elevation as a result of net erosion. San Geronimo and Lagunitas creeks and alluvial reaches of their tributaries have incised substantially during the historical period. Channel incision obliterates the basic physical habitat structure of the channel, expressed by a substantial reduction in the frequency and area of gravels bars, riffles, and side channels. If a channel incises substantially, it will become disconnected from its surrounding floodplain further increasing the rates of incision, streambed mobility, and scour depth. Another effect of incision has been a significant reduction in large woody debris input to Lagunitas Creek and its tributaries, which also greatly diminishes the capacity for these creeks to store, sort, and meter sediment.

Habitat conditions are degraded by elevated concentrations of fine sediment in the streambed (primarily sand) - caused by pervasive alteration of sediment supply, transport, and storage - which further reduces juvenile salmonid growth and survival in all freshwater life stages. As sediment supply increases or becomes finer, the streambed can respond by becoming finer and more mobile, as has been documented in tributaries to Lagunitas Creek. Streambed scour at spawning redds can be a significant source of mortality during incubation for coho salmon.

Numeric Targets

Meeting the numeric targets listed in Table 1 will allow water quality in the Lagunitas Creek and its tributaries to achieve the narrative water quality objectives for sediment, settleable material, and population and community ecology.

Table 1: Sediment and Habitat Targets for the Lagunitas Creek and its Tributaries

Sediment Condition Targets
Streambed Mobility (τ^*): $0.03 < \tau^* \leq 0.06$; this target applies to gravel-bedded channel reaches where the adjacent valley flat is a floodplain.
Watershed-wide median depth of redd scour (D_s) ≤ 12 cm
Habitat Condition Targets
Large Woody Debris (LWD) Loading ≥ 300 m ³ /ha in Redwood Channels ^c and ≥ 100 m ³ /ha in Hardwood Channels
<p>Explanatory notes:</p> <p>The numeric target for reach-average value of streambed mobility at bankfull stage, or Tau-Star (τ^*), is greater than 0.03 and less than or equal to 0.06, corresponding to a partially-to-fully mobile streambed. This is the natural range of mobility in most gravel-bedded channels. The target applies only to gravel-bedded channel reaches where the adjacent valley flat is a floodplain, and where: a) the streambed slope is between 0.001 and 0.03; and b) actual or potential spawning habitat is provided for anadromous salmonid species. As defined by renowned geomorphologists Thomas Dunne and Luna B. Leopold: "The floodplain is the flat area adjoining a river channel constructed by the river in the present climate and overflowed at times of high discharge. It is inundated on the average once every one or two years."</p> <p>The watershed-wide median value for depth of scour (D_s) at actual or potential spawning sites for coho salmon and/or steelhead shall be ≤ 12 cm below the level of the overlying streambed substrate. This target applies for discharges \leq the 5-year recurrence interval event (annual maximum series). Channel reaches that provide actual or potential spawning habitat are as defined above. Potential spawning sites within those reaches can be identified based on the following characteristics: 1) median particle size diameter (D_{50}) in the surface layer of the streambed is between 16 and 64 mm; 2) surface area of the gravel deposit is ≥ 1.0 square meter; and 3) location at a riffle head, pool tail, pool margin, and/or a gravel deposit associated with a flow obstruction (e.g., woody debris, boulders, banks, etc.).</p> <p>Redwood channels are defined as those where the adjacent valley floor and/or hillslopes are vegetated primarily by coast redwood forest. Hardwood channels are defined as those where the adjacent valley flat is vegetated by a hardwood forest (typically some combination of willow species, white alder, California bay laurel, bigleaf maple, tan oak, and/or Oregon ash). The large woody debris loading targets apply to channel reaches that provide actual or potential spawning habitat for anadromous salmonids as defined above.</p>

Sediment Sources

Field inventories conducted throughout the watershed provide credible estimates of the rates and sizes of sediment delivered to channels in the Lagunitas Creek watershed during water years 1983 through 2008. Based on this work, the Water Board concludes:

1. Sediment supply to Lagunitas Creek was greater than or equal to two times natural background. Hillslope erosion processes considered together with road-related erosion, accounted for about 40 percent of sediment delivery to Lagunitas Creek. Human-caused channel incision and associated bank erosion, primarily the result of historical land-use disturbances, accounted for about 60 percent of the supply.
2. Rates of sediment supply to channels in the Lagunitas Creek watershed varied substantially, from less than 100-to-about-400 metric tons per km² per year. Variability is a function primarily of the location of dams, large alluvial valleys (where channels have become deeply incised), road density, and bedrock geology.
3. Channel incision rates were highest in headwater channel reaches, but incision also was active further downstream (at somewhat lower rates) in the reaches that provide habitat for anadromous salmonids and California freshwater shrimp.
4. Considering the significant exposure of hard bedrock in the streambed along San Geronimo Creek, and in the mainstem of Lagunitas Creek in the Shafter and State Park reaches, it is unlikely that streambed elevation will become much lower in these reaches. Absent intervention complex habitat that now includes riffles and bars will likely decrease and bedrock exposure will increase, which would further impair habitat condition.
5. While the primary driver for incision is a reduction in large woody debris loading, reduction in coarse sediment supply following construction of Kent Lake and Nicasio Reservoir, and other historical and ongoing land-use activities also are factors.

In summary, the net result is an elevated amount of fine sediment in the streambed, and substantial simplification of channel habitat structure.

The total sediment load in Lagunitas Creek is estimated to have been about 230 percent of natural background upstream of Devils Gulch and about 200 percent of natural background upstream of Olema Creek during the study period. Tables 2a and 2b break down the sediment sources to Lagunitas Creek based on an annual average rate.

Table 2a: Mean Annual Sediment Delivery to Lagunitas Creek upstream of Devils Gulch (drainage area = 89 km²) during water years 1983 through 2008

Source	Estimated Mean Annual Delivery Rate (metric tons/yr)
Landslides, Gullies, and Soil Creep	2,600
Roads	3,600
Tributary Channels: Channel Incision and Bank Erosion	5,000
San Geronimo Creek and Lagunitas Creek: Channel Incision and Bank Erosion	2,900
Urban stormwater and wastewater discharges	100
TOTAL	14,200

Table 2b: Mean Annual Sediment Delivery to Lagunitas Creek upstream of Olema Creek (drainage area = 213 km²) during water years 1983 through 2008

Source	Estimated Mean Annual Delivery Rate (metric tons/yr)
Landslides, Gullies, and Soil Creep	5,600
Roads	4,000
Tributary Channels: Channel Incision and Bank Erosion	8,500
San Geronimo Creek and Lagunitas Creek: Channel Incision and Bank Erosion	4,000
Urban stormwater, wastewater, and other point source discharges	100
TOTAL	22,200

Total Maximum Daily Load and Allocations

The sediment TMDL for Lagunitas Creek upstream of Devils Gulch is established at 7,500 metric tons per year, which corresponds to about 120 percent of natural background load during the water year 1983 through 2008 period. The sediment TMDL for Lagunitas Creek upstream of Olema Creek is established at 11,900 metric tons per year, which corresponds to about 110 percent of natural background load during the water year 1983 through 2008 period. Natural background load depends upon natural processes, and varies significantly. Therefore, these TMDLs and associated allocations are expressed both in terms of sediment mass and percent of natural background. Sediment delivery needs to be reduced overall by about 50 percent from current proportion of the total load to achieve these TMDLs. Tables 3a through 3c contain the load allocations for all sources of sediment in the watershed.

TMDL attainment will be evaluated: a) immediately upstream of the confluence of Lagunitas Creek with Devils Gulch, which approximates the mid-point along the primary spawning reach for coho salmon on Lagunitas Creek; and b) immediately upstream of the confluence of Lagunitas Creek with Olema Creek, which corresponds to the downstream boundary of the TMDL project area. Attainment of the TMDL will be evaluated over a 5-to-10-year averaging period.

Table 3a: Load Allocations for Sediment Discharges Upstream of Devils Gulch

Source category	Load during 1983-2008		Estimated reductions needed (percentage)	Load allocations	
	Metric tons/year	Percentage of Natural Background		Metric tons/year	Percentage of Natural Background
Landslides, Gullies, and Soil Creep	2,600	42	50	1,300	21
Roads	3,600	58	50	1,800	29
Tributary Channels:					
Channel Incision and Bank Erosion	5,000	80	33	3,300	53
San Geronimo Creek and Lagunitas Creek:					
Channel Incision and Bank Erosion	2,900	47	67	1000	16
Total	14,100	227	48	7,400	119

Table 3b: Load Allocations for Sediment Discharges Upstream of Olema Creek

Source category	Load during 1983-2008		Estimated reductions needed (percentage)	Load allocations	
	Metric tons/year	Percentage of Natural Background		Metric tons/year	Percentage of Natural Background
Landslides, Gullies, and Soil Creep	5,600	53	50	2,800	26
Roads	4,000	38	50	2,000	19
Tributary Channels:					
Channel Incision and Bank Erosion	8,500	80	33	5,700	53
San Geronimo Creek and Lagunitas Creek:					
Channel Incision and Bank Erosion	4,000	38	67	1,300	12
Total	22,100	209	47	11,800	110

Table 3c: Wasteload Allocations for Stormwater upstream of Olema Creek

Source Category	Current Load		Reductions needed (percentage)	Wasteload Allocations	
	Metric tons/year	Percentage of Natural Background		Metric tons/year	Percent of Natural Background
Construction Stormwater-NPDES Permit No. CAS000002	30	0.3	0	80	0.3
Municipal Stormwater NPDES Permit No. CAS000004	70	0.7	0	20	0.7
TOTAL	100	1.0	0	100	1.0

Note: Above estimates for loads, percent reductions, and allocations are rounded to two significant figures

IMPLEMENTATION PLAN

The actions described below, including those to control sediment discharges and enhance stream-riparian habitat complexity and connectivity, are to attain allocations and achieve numeric targets for sedimentation and habitat condition.

Regulatory Tools

The only known point sources of sediment are very small and associated with municipal and construction stormwater runoff, which are regulated under existing NPDES permits that include requirements to control erosion, sedimentation, and hydromodification.

Table 4.0 shows implementation measures required of these sources. The State's Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program requires regulation of nonpoint source discharges using the Water Board's administrative permitting authorities, including waste discharge requirements (WDRs), waiver of WDRs, Basin Plan Discharge Prohibitions, or some combination of these. Consistent with this policy, Tables 4.1 - 4.3 specify actions and performance standards by nonpoint source category to achieve TMDL sediment targets and allocations in the Lagunitas Creek watershed.

Control of Nonpoint Sources of Sediment

The only significant nonpoint source that is not effectively controlled through existing programs and/or natural recovery processes is sediment discharge from roads. This gap applies only to publicly owned roads, primarily unpaved roads under the jurisdiction of the State Department of Parks and Recreation in SP Taylor State Park, and/or the US National Park Service within the Golden Gate National Recreation Area. Paved public roads, almost all under the jurisdiction of the County of Marin, also may contribute significant amounts of sediment to channels, although at lower rates.

With regard to the unpaved public roads, reasonable assurances are in place through a memorandum of understanding (MOU) - for the maintenance and management of unpaved roads – that has been agreed to by all of the public agencies within the project area with jurisdiction over roads. Through this MOU, substantial progress has been made to control and reduce sediment delivery to channels. The Marin Open Space District and Marin Municipal Water District already achieve the performance standard for unpaved roads under their jurisdiction in the Lagunitas Creek watershed.

To ensure that effective sediment source controls are implemented on all public roads – unpaved and paved - consistent with the State Nonpoint Source Program, WDRs, or a conditional waiver of WDRs is required to meet the road sediment delivery performance standard (Table 4.2). Whether through adoption of a conditional waiver of WDRs or adoption of WDRs, the required actions are as follows.

1. The County of Marin, Department of Public Works, within five years of TMDL adoption, must conduct an inventory of its paved roads within the project area to identify sediment delivery sites, and produce a schedule for treatment, as needed to achieve road sediment delivery performance standard listed in Table 4.2.

2. The California Department of Parks and Recreation within SP Taylor State Park, and the US National Park Service within that portion of the Golden Gate National Recreation Area that is in the TMDL project area, must control sediment delivery sites on unpaved roads to achieve the performance standard for road-related sediment delivery (Table 4.2).
3. All public agencies with jurisdiction over roads within the project area must adopt and implement road maintenance guidelines to protect aquatic habitat, water quality, and salmonid fisheries; conduct an annual training program for road maintenance staff, and once every three years submit a report that documents implementation, and/or recommends adaptive updates to the maintenance practices.

Actions to Enhance Stream-Riparian Habitat Complexity and Connectivity

Although future sediment delivery from channel incision is predicted to decline substantially as a result of natural process adjustments, absent implementation of a habitat enhancement program, stream-riparian habitat condition will remain substantially degraded. Stream habitat degradation in the channel reaches that remain accessible to populations of coho salmon and steelhead is a key factor in their decline. Therefore, the primary focus of this Plan is a program of channel habitat enhancement, presented in Table 4.3, focused on actions to substantially increase the amount of large woody debris in channels and to develop focused technical studies to identify priorities and opportunities for floodplain restoration (in channel reaches where it is safe and feasible to do so). Goals for these actions are presented in Table 4.4.

Problems associated with channel incision, reflect and integrate multiple historical and ongoing disturbances, some of which are local and direct, and others that are indirect and distal. Effectively addressing these issues will require cooperative and coordinated actions by multiple landowners, working with public agencies, over significant distances along the river. The Water Board will emphasize cooperative programs to achieve the floodplain restoration and/or large woody debris enhancement goals acting in coordination with the State Water Board Division of Water Rights (Table 4.4).

The Water Board also encourages stakeholders along San Geronimo Creek and its tributaries, to develop reach-based stewardship groups to implement channel habitat enhancement projects in this part of the watershed. Public funding for such efforts should be prioritized for reaches, where both potential gains in habitat function are significant, and necessary landowner support and participation can be achieved.

**Table 4.0 TMDL Implementation Measures for Sediment Discharges
Associated with Point Sources**

Source Category	Actions	Implementing Parties
Municipal stormwater and construction stormwater	Comply with applicable NPDES permit.	County of Marin, and owners or operators of construction projects > 1 acre

Table 4.1: Required TMDL Implementation Measures for Sediment Discharges Associated with Grazing¹

Land Use Category	Performance Standards	Actions	Implementing Parties	Completion Dates
Grazing	Surface erosion associated with livestock grazing: Attain or exceed minimum residual dry matter values consistent with University of California Division of Agriculture and Natural Resources Guidelines; and Roads: Road-related sediment delivery to channels ≤ 350 cubic yards per mile per 20-year period; and Minimize delivery of sediment to channels from unstable or potentially unstable areas: Manage existing grazing operations, stock ponds, and roads to prevent additional erosion of legacy sediment delivery sites, and/or delivery from other potentially unstable areas.	Comply with the existing Water Board regulatory program: conditional waiver of waste discharge requirements for grazing operations in the Tomales Bay watershed (R2-2013-0039),or Other applicable WDRs or waiver of WDRs, or Submit a Report of Waste Discharge to the Water Board that provides, at a minimum, the following: description of the property; identification of site-specific erosion control measures to achieve performance standard(s) specified in this table; and a schedule for implementation of identified erosion control measures.	Landowner and/or ranch operator	As required by existing regulatory program under R2-2013-0039 or other applicable WDRs or waiver of WDRs. Individual waste discharge requirements also may be issued as needed, with the schedule to be determined.
		Report progress on implementation of site-specific erosion control measures. ²	Landowner and/or ranch operator	As specified in applicable WDRs or waiver of WDRs
		¹ To achieve TMDL allocations, consistent with the State Nonpoint Source Program. ² These reports may be prepared individually or jointly or through a recognized third party.		

Table 4.2: Required TMDL Implementation Measures for Sediment Discharges associated with Parks and Open Space, and/or Municipal Public Works¹

Landowner Type	Performance Standards	Actions	Implementing Parties	Completion Dates
PARKS AND OPEN SPACE AND PUBLIC WORKS	Roads: Road-related sediment delivery to channels ≤ 350 cubic yards per mile per 20-year period; and Minimize delivery of sediment to channels from unstable or potentially unstable areas: Manage existing roads and other infrastructure to prevent additional erosion of legacy sediment delivery sites, and/or delivery from other potentially unstable areas.	Submit a Report of Waste Discharge to Water the Water Board that provides, at a minimum, the following actions are required: a) description of the road network and/or segments; b) identification of erosion and sediment control measures to achieve performance standard(s) specified in this table; c) a schedule for implementation of identified control measures; and d) development and implementation of guidelines for road maintenance, as needed to protect water quality, stream-riparian habitat, and salmonid fisheries	County of Marin, Public Works Department State of California, Department of Parks and Recreation, SP Taylor State Park US National Park Service, Golden Gate National Recreation Area	Submit a report of waste discharge within five years of Basin Plan amendment adoption. Achieve performance standards within twenty years of Basin Plan amendment adoption.
		Comply with applicable WDRs or waiver of WDRs.	As above	As specified in applicable WDRs or waiver of WDRs
		Report progress on development and implementation of best management practices to control road-related erosion.	As above	As specified in applicable WDRs or waiver of WDRs
¹ To achieve TMDL allocations, consistent with the State Nonpoint Source Program.				

Table 4.3: Actions to Enhance Habitat Complexity and Connectivity in Lagunitas Creek and its Tributaries

Stressor	Management Objective(s)	Actions	Implementing Parties	Completion Dates and Notes
Habitat degradation as a result of incision of Lagunitas Creek and its tributaries.	<p>Enhance channel habitat complexity and connectivity as needed to support self-sustaining populations of coho salmon and steelhead, and to enhance the overall health of the native fish community.</p> <p>Reduce rates of sediment delivery (associated with incision and accelerated bank erosion) to channels, by 67 percent in Lagunitas and San Geronimo creeks, and by 33 percent in tributaries to both streams.</p>	<p>1. Develop and implement plans to enhance large woody debris loading and restore natural rates of recruitment to channels, as needed to achieve numeric targets for large woody debris loading (Table 1) and to achieve load allocations for sediment (Tables 3a and 3b). The above plan will include a survey to quantify baseline values for large woody debris loading.</p> <p>2. Develop detailed technical studies to characterize reach-specific opportunities and priorities for floodplain restoration.</p>	<p>Along San Geronimo Creek and its tributaries, local government agencies or non-profits in partnership with reach-based landowner stewardships will develop and implement projects to enhance habitat complexity and connectivity.</p> <p>Elsewhere in the Lagunitas Creek watershed, the Marin Municipal Water District will lead efforts to develop and implement projects to enhance habitat complexity and connectivity.</p>	<p>Targets for large woody debris loading will be achieved within 10 years of Basin Plan amendment adoption.</p> <p>Technical studies to characterize reach specific opportunities and priorities for floodplain restoration will be completed within 5 years of Basin Plan amendment adoption.</p> <p>Comply with conditions of Clean Water Act Section 401 certifications in the implementation of projects to enhance large woody debris loading and recruitment.</p>

Table 4.4: Goals for Floodplain Restoration and/or Large Woody Debris Enhancement in Lagunitas Creek Watershed

1. To increase side channel plus alcove area, wetted during winter baseflow and higher flows, by 100 percent-or-more. Side channels and alcoves should be accessible, nearby or adjacent to debris jams and/or undercut banks in the main channel, and/or tributary junctions.
2. To establish diverse vegetation and substrate patch types that are dynamically established, evolve, and deform through time: a complex and dynamic mosaic of stream-riparian habitats.
3. To store a substantial fraction of the fine sediment supply on the floodplain: 20 percent-or-more of the total sediment supply to a given channel reach.
4. To achieve the streambed mobility and redd scour targets in all reaches where floodplains are reconnected to channels.
5. To increase gravel storage volume and average residence time, and to increase the variability in the thalweg profile in SP Taylor State Park, Tocaloma, and Lower Lagunitas reaches.
6. To restore natural rates of recruitment of large woody debris from riparian areas of channels located on public lands.
7. To achieve or exceed targets for large woody debris loading as specified in Table 1 within 10 years of Basin Plan amendment adoption.
8. To convert one-third-or-more of the plane bed habitat in channel reaches accessible to anadromous salmonids to forced pool-riffle habitat.
9. To expand the reach length occupied by California freshwater shrimp by two kilometers-or-more.
10. To produce 10,000-or-more coho salmon smolts, and 6,000-or-more steelhead smolts, on average, each year.

Agricultural Water Quality Control Program Costs

Implementation measures for grazing lands and roads located on those same properties constitute an agricultural water quality control program and therefore, consistent with California Water Code requirements (Section 13141), the cost of this program is estimated herein. The Tomales Bay watershed pathogens TMDL was adopted in 2005, which includes all ranches and grazing areas within the Lagunitas Creek watershed, estimates costs to ranch operators to implement best management practices to control pathogen discharges from rangelands including maintaining adequate amounts of residual dry matter in rangelands and the costs of excluding livestock from water courses by construction and maintenance of fences in these sensitive areas. Those actions also are expected to satisfy performance standards for control of surface erosion in rangelands, and control of sediment discharge from unstable areas. As such, we do not consider these existing costs, associated with compliance with the previously adopted pathogens TMDL, in calculating the agricultural water quality control program costs associated with achieving compliance with the Lagunitas Creek sediment TMDL. The only new agricultural water quality control program costs are those related to attainment of performance standards and load allocations for sediment discharge from roads to channels. In the Lagunitas Creek watershed, we estimate that there are 20 miles of roads located on privately owned ranchlands. In estimating potential cost of compliance, we reference recently completed road erosion inventories conducted on unpaved roads located on ranches and/or parklands in the Lagunitas Creek watershed that include estimates of the costs for treating all significant sediment delivery sources from those roads. Relying on these data, we estimate that the maximum total cost to ranch operators, assuming no public funding is available to support this work, could cost \$420,000¹ over the 20-year implementation period associated with achievement of the TMDL, or about an average of \$21,000 per year. However, the actual cost to agricultural landowners should be lower because it is reasonable to conclude that some projects will qualify for grant funding from public agencies.

Evaluation and Monitoring

Three types of monitoring are specified to assess progress toward achievement of numeric targets and load allocations for sediment:

- 1) Implementation monitoring to document actions to reduce fine sediment discharge and enhance habitat complexity and connectivity.
- 2) Upslope effectiveness monitoring to evaluate effectiveness of sediment control actions in reducing rates of sediment delivery to channels
- 3) In-channel effectiveness monitoring (e.g., streambed mobility and redd scour) to evaluate channel response to management actions and natural processes

Implementation monitoring will be conducted by landowners or designated agents. The purpose of this type of monitoring is to document that sediment control and/or habitat enhancement actions specified herein actually occur.

The Water Board working in partnership with other government agencies plans to conduct upslope effectiveness monitoring. This will include an update to all or part of the watershed sediment budget, to re-evaluate rates of sediment delivery to channels from land-use activities and natural processes (ten years subsequent to Basin Plan amendment adoption) in the fall of 2024, when sediment delivery associated with land-use activities are projected to be reduced by 25 percent-or-more.

In-channel effectiveness monitoring should be conducted by local government agencies with scientific expertise and demonstrated capability in working effectively with private property owners (to gain permissions for access), as needed to develop a representative sample of stream habitat conditions, in relation to sediment supply and transport within the watershed. In-channel effectiveness monitoring needs to include measurements of redd scour and streambed mobility to evaluate attainment of water quality objectives for settleable material.

Streambed mobility (τ^*) should be measured in gravel-bedded channel reaches along Lagunitas Creek and in its tributaries where the adjacent valley flat is a floodplain.

Redd scour should be measured at 30-or-more potential spawning sites, with 4-or-more scour measurements per spawning site, as needed, to establish a high level of statistical confidence in estimated values. Redd scour sampling sites should be stratified based on estimated average annual sediment supply rate.

Large woody debris loading in channels also needs to be surveyed and assessed to evaluate attainment of the numeric targets for large woody debris loading, and to guide development of reach-specific prescriptions for installation of engineered log jams and riparian management actions to maintain or exceed the target values in future years through natural recruitment.

Desired measurement frequency for streambed mobility, redd scour, and large woody debris is once every three years.

Adaptive Implementation

In concert with the monitoring programs, described above, the Water Board will adapt the Lagunitas Creek Sediment Reduction and Habitat Enhancement Plan and TMDL. In amending the Basin Plan amendment, the Water Board will consider, at a minimum, the results of validation monitoring conducted to confirm or reject hypotheses regarding effects of actions to enhance large woody debris loading and floodplain area on population dynamics of coho salmon, steelhead, and California freshwater shrimp. The Water Board will also consider the results of salmonid population monitoring programs including juvenile population estimates, adult spawner surveys, and smolt outmigration surveys performed to evaluate the status and trends of these populations, and also related analyses of smolt population dynamics in response to changes in the quantity and quality of freshwater habitat.